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GB 2074307 A GB 2017827 A EP 0937946 A2
EP 0178820 A1 US 5235805 A

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INT CL^7 F23R 3/04 3/06 3/08
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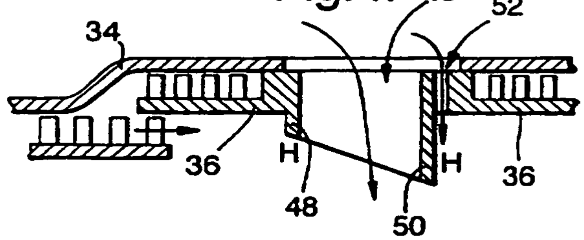
(54) Abstract Title

Combustor wall arrangement with air intake port

(57) A wall structure for a gas turbine engine combustor (30) includes inner and outer walls (32 and 34 respectively). The inner wall (32) is made up of a number of wall elements or tiles (36). A mixing port (46) is provided within the wall structure for providing air to the combustor, the mixing port (46) including baffle means (50, projecting internally beyond the inner wall or externally beyond the outer wall, for directing air generally towards an inner region of the combustor (30). The mixing port may be attached to the outer wall by a circlip or split ring fastening (figs 12-15).

Fig.4.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

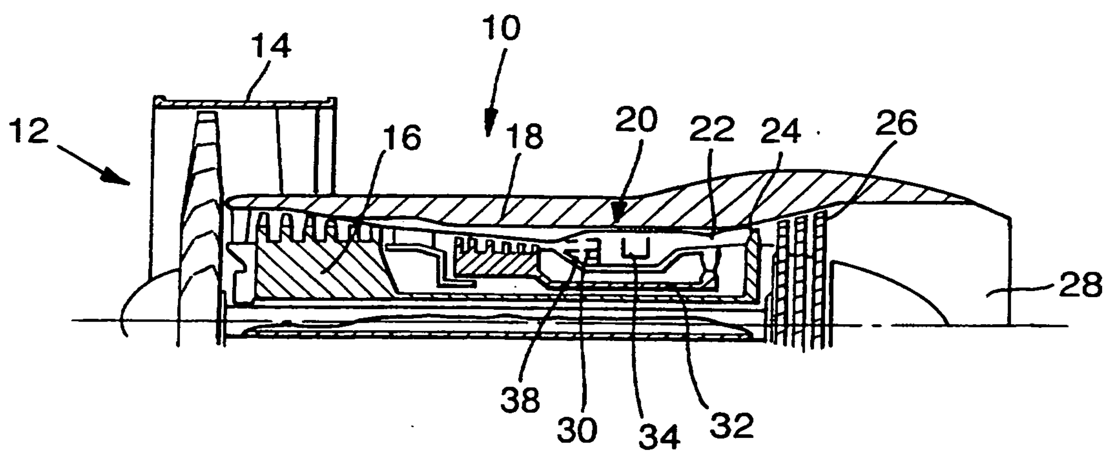

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Fig.2.

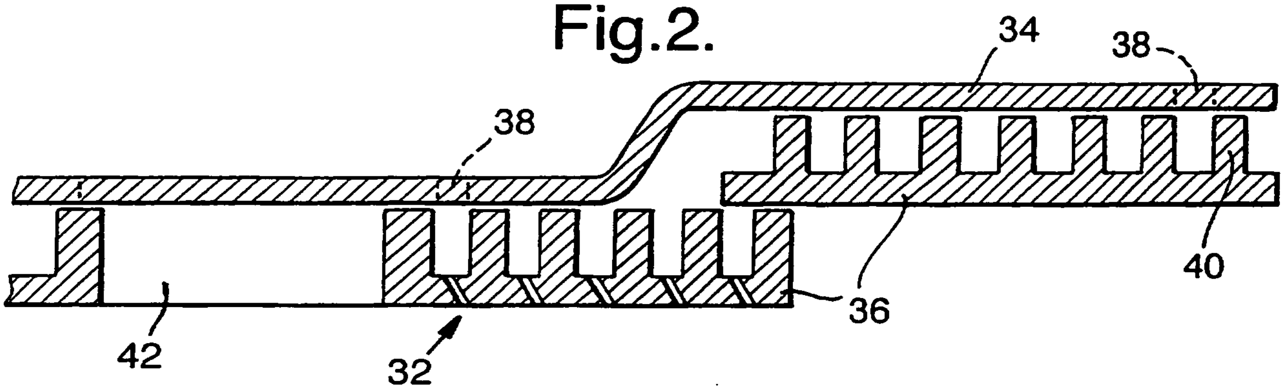


Fig.3.

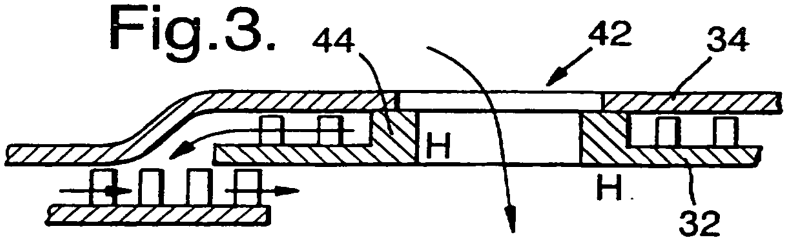


Fig.4.

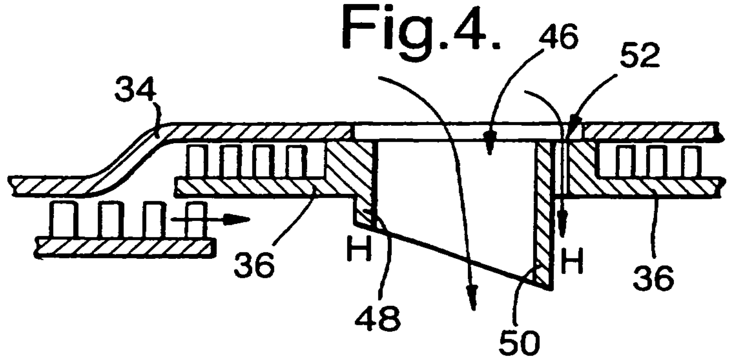


Fig.5.

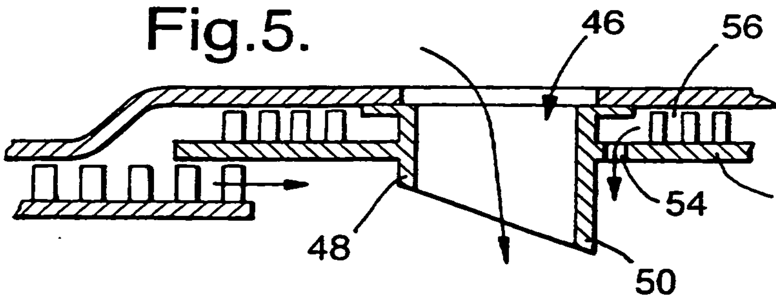


Fig.6.

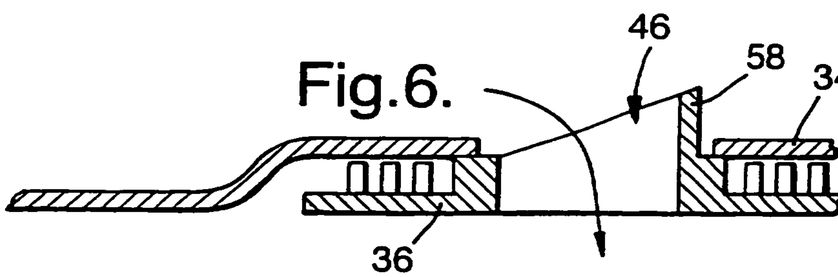


Fig.7.

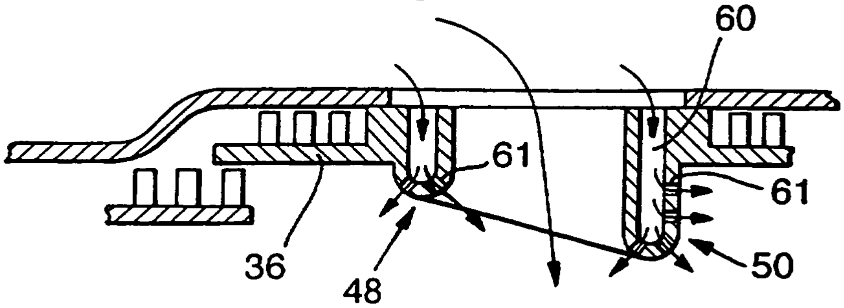


Fig.8.

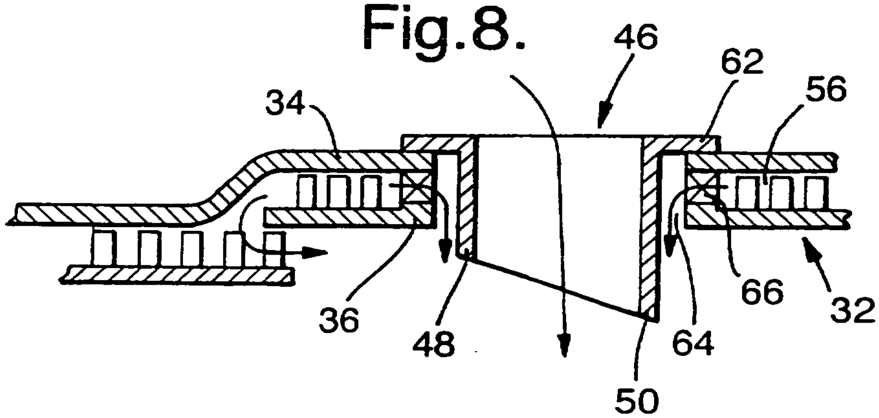


Fig.9.

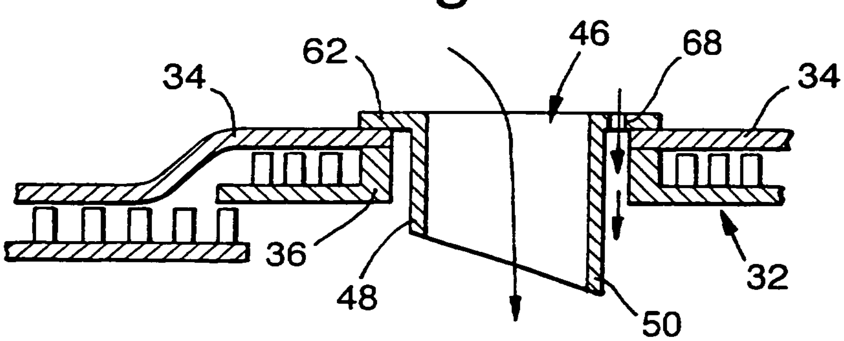


Fig.10.

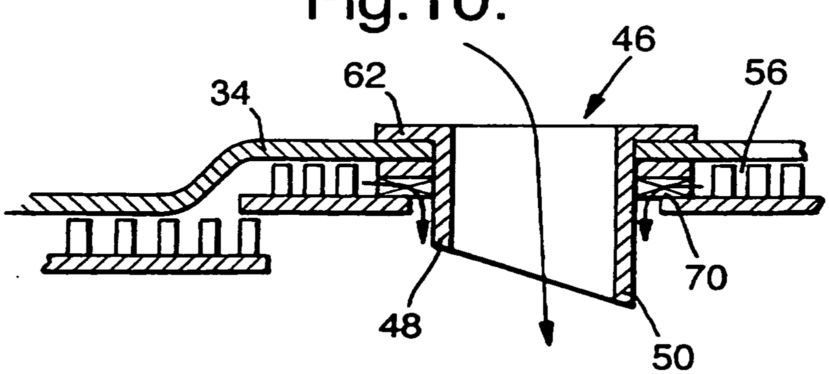


Fig.11.

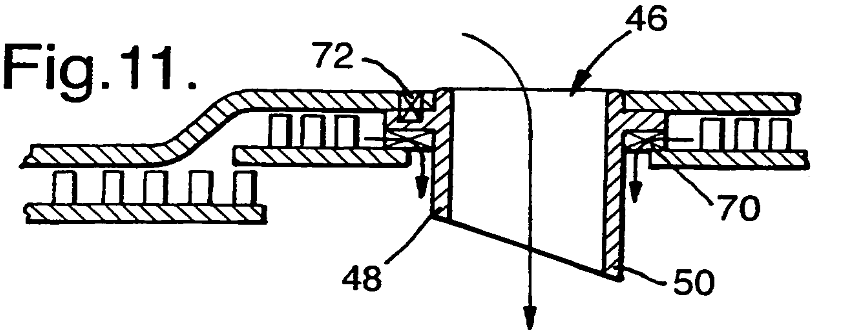


Fig.12.

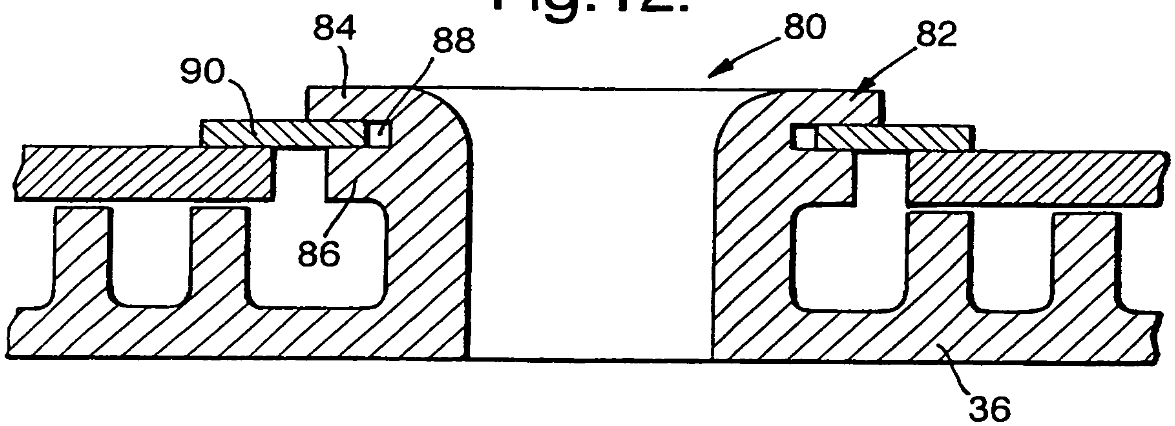


Fig.13.

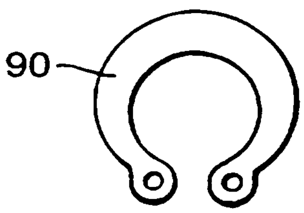


Fig.14.

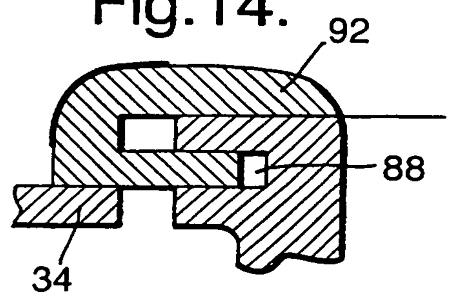
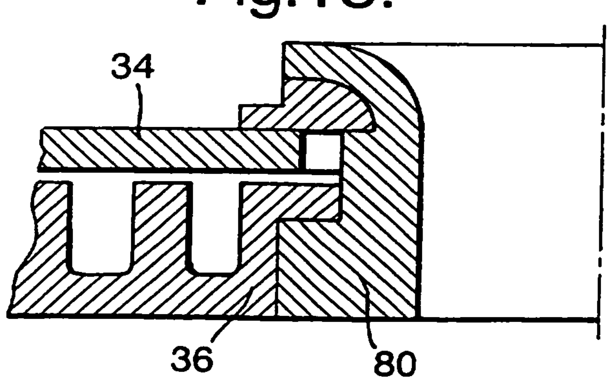


Fig.15.



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Combustion Apparatus

The invention relates to a combustion apparatus for a gas turbine engine. More particularly the invention relates to a wall structure for such a combustion apparatus.

A typical gas turbine engine combustor includes a generally annular chamber having a plurality of fuel injectors at an upstream head end. Combustion air is provided through the head and in addition through primary and intermediate mixing ports provided in the combustor walls, downstream of the fuel injectors.

In order to improve the thrust and fuel consumption of gas turbine engines, i.e. the thermal efficiency, it is necessary to use high compressor pressures and combustion temperatures. Higher compressor pressures give rise to higher compressor outlet temperatures and higher pressures in the combustion chamber, which result in the combustor chamber experiencing much higher temperatures than are present in most conventional prior combustor designs.

There is therefore a need to provide effective cooling of the combustion chamber walls. Various cooling methods have been proposed including the provision of a doubled walled combustion chamber whereby cooling air is directed into a gap between the chamber walls thus cooling the inner wall. This air is then exhausted into the combustion chamber through apertures in the inner wall. The inner wall may also comprise a number of heat resistant tiles. Constructing the inner wall from tiles has the advantage of being relatively simple and inexpensive.

In a known tiled wall structure for a combustion chamber, the mixing ports are defined by approximately circular openings provided in the outer wall and in the tiled inner wall.

According to one aspect of the invention, there is provided a wall structure for a gas turbine engine combustor, the wall structure including at least one outer wall and at

least one inner wall, the inner wall including a number of wall elements, wherein at least one mixing port is provided within the wall structure for providing air to the combustor and wherein the mixing port includes baffle means projecting internally beyond the inner wall or externally beyond the outer wall, for directing air generally towards an inner region of the combustor.

Preferably the wall elements comprise discrete tiles. The tiles may be provided with raised lands or pedestals.

Preferably the baffle means is provided at a downstream side of the mixing port.

The baffle means may be integral with a wall element of the inner wall. Alternatively the baffle means may be formed separately from the wall structure and may be affixed to the outer wall.

The baffle means preferably forms at least part of a chute member which may have a generally cylindrical shape. Preferably a downstream part of the chute member extends further internally or externally than an upstream part.

In a preferred embodiment, the baffle means projects internally beyond the inner wall, and means are provided for directing cooling air over the baffle means.

The cooling air may be directed from a region external to the outer wall. In this case, an opening may be provided between the chute member and an adjacent part of the wall structure, the opening allowing air to flow from a region external to the outer wall into the combustor, over the baffle means. Alternatively the chute member may have two generally parallel walls, such that air may flow from a region external to the outer wall of the wall structure into a space between the two walls of the chute member, thereby to cool the baffle means.

The cooling air may be directed from a space between the inner and outer walls. In this case, an opening may be provided in the inner wall or between the chute member and an adjacent part of the inner wall, the opening allowing air to

flow from the space between the inner and outer walls into the combustor, over the baffle means. A sliding seal ring may be provided in the opening. Retaining means may be provided to prevent rotation of the chute member relative to the wall structure.

The baffle means may be provided with a thermally resistant material, preferably on an external surface thereof. The thermally resistant material may be in the form of a coating, suitably a thermal barrier coating.

The thermally resistant material may be, for example magnesium zirconate or yttria stabilised zirconia.

Another aspect of the invention relates to the fixing of combustor wall elements or tiles to the outer wall of the combustor, and particularly to the minimisation of the separation between the wall element and the outer wall resulting from thermal distortion of the tile.

To minimise cost, combustor wall tiles may be relatively flimsy and have a poor resistance to thermal distortion. The problem of thermal distortion of these tiles is compounded by a requirement to site fixing bolts in a relatively cool area close to the upstream edge of each tile, this region being best protected by the air film issuing from either a preceding tile or from a dome/heat shield. On tiles which incorporate integral mixing ports, the ports would generally be located near the downstream edge of the tile, in a region most likely to suffer thermal distortion. The effect of permitting distortion near a mixing port could be to impair the air feed quality to the port and reduce both the air mass flow rate and velocity.

According to this aspect of the invention, there is provided a wall structure for a combustor, the wall structure including at least one outer wall and at least one inner wall and the inner wall including a number of wall elements, wherein at least one mixing port is provided within the wall structure for providing air to the combustor, the mixing port being affixed to the inner wall and being affixed to the

outer wall with a circlip or split ring fastening.

The mixing port may be integrally formed with a wall element of the inner wall. Alternatively the mixing port may be crimped or swaged to the wall element of the inner wall.

Embodiments of the invention will now be described for the purpose of illustration only with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic diagram of a ducted fan gas turbine engine having an annular combustor;

Fig. 2 is a diagrammatic detail of part of the combustor wall structure of the gas turbine engine of Fig. 1;

Fig. 3 is a diagrammatic illustration of a prior art mixing port as used in the combustor of Fig. 1;

Fig. 4 is a diagrammatic cross section of a smoke chute according to a first embodiment of the invention;

Fig. 5 is a diagrammatic cross section of a smoke chute according to a second embodiment of the invention;

Fig. 6 is a diagrammatic cross section of a smoke chute according to a third embodiment of the invention;

Fig. 7 is a diagrammatic cross section of a smoke chute according to a fourth embodiment of the invention;

Fig. 8 is a diagrammatic cross section of a smoke chute according to a fifth embodiment of the invention;

Fig. 9 is a diagrammatic cross section of a smoke chute according to a sixth embodiment of the invention;

Fig. 10 is a diagrammatic cross section of a smoke chute according to a seventh embodiment of the invention;

Fig. 11 is a diagrammatic cross section of a smoke chute according to a eighth embodiment of the invention;

Fig. 12 is a diagrammatic cross section of a combustor wall structure according to a second aspect of the invention;

Fig. 13 is a diagrammatic plan view of a circlip for use in the wall structure of Fig. 12;

Fig. 14 is a diagrammatic cross section of a combustor wall structure similar to that of Fig. 12 but using alternative fixing means; and

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Fig. 15 is a diagrammatic cross section of a combustor wall structure similar to that of Figs. 12 and 13 but illustrating a non-integral chute member.

With reference to Fig. 1 a ducted fan gas turbine engine generally indicated at 10 comprises, in axial flow series, an air intake 12, a propulsive fan 14, an intermediate pressure compressor 16, a high pressure compressor 18, combustion equipment 20, a high pressure turbine 22, an intermediate pressure turbine 24, a low pressure turbine 26 and an exhaust nozzle 28.

The gas turbine engine 10 works in the conventional manner so that air entering the intake 12 is accelerated by the fan 14 to produce two air flows, a first air flow into the intermediate pressure compressor 16 and a second airflow which provides propulsive thrust. The intermediate pressure compressor 16 compresses the air flow directed into it before delivering the air to the high pressure compressor 18 where further compression takes place.

The compressed air exhausted from the high pressure compressor 18 is directed into the combustion equipment 20 where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through and thereby drive the high, intermediate and low pressure turbines 22, 24 and 26 before being exhausted through the nozzle 28 to provide additional propulsive thrust. The high, intermediate and low pressure turbines 22, 24 and 26 respectively drive the high and intermediate pressure compressors 16 and 18 and the fan 14 by suitable interconnecting shafts.

The combustion equipment 20 includes an annular combustor 30 having radially inner and outer wall structures 31 and 33 respectively. Fuel is directed into the combustor 30 through a number of fuel nozzles (not shown) located at the upstream end of the combustor 30. The fuel nozzles are circumferentially spaced around the engine 10 and serve to spray fuel into air derived from the high pressure compressor

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18. The resultant fuel and air mixture is then combusted within the combustor 30.

The combustion process which takes place within the combustor 30 naturally generates a large amount of heat. Temperatures within the combustor may be between 1,850K and 2,600K. It is necessary therefore to arrange that the inner and outer wall structures 31 and 33 are capable of withstanding this heat flow while functioning in a normal manner. Each of the inner and outer wall structures 31 and 33 comprises an inner wall 32 and an outer wall 34. The construction of the inner and outer wall structures 31 and 33 is generally the same and, as an example, the construction of the outer wall structure 33 is shown more clearly in Fig. 2.

Referring to Fig. 2 the inner wall 32 comprises a plurality of discrete tiles 36 which are all of substantially the same rectangular configuration and are positioned adjacent each other. The majority of the tiles 36 are arranged to be equidistant from the outer wall 34. Each tile 36 is of cast construction and is provided with integral studs (not shown) which facilitate its attachment to the outer wall 34. Feed holes 38 are provided in the outer combustor wall 34 such that cooling air is allowed to flow into the gap between the tiles 36 and outer wall 34. The temperature of this air is around 800K to 900K and the pressure outside the combustor is about 3% to 5% higher than the pressure inside the combustor (perhaps 600 psi as opposed to 570 psi)..

Each tile 36 also has a plurality of raised lands or pedestals 40 which improve the cooling process by providing additional surface area for the cooling air to flow over.

Air is directed into the combustion chamber 30 through mixing ports 42. The function of the mixing ports 42 is to direct air into the combustion chamber in a manner which achieves optimum mixing with the fuel, in order to help control combustion emissions. A first array of primary mixing ports is arranged around the annular combustor,

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downstream of and axially aligned with the fuel injectors. A second array of intermediate mixing ports is arranged downstream of the primary mixing ports, axially out of alignment with the primary mixing ports. Fuel provided through the injectors first encounters jets of air from the primary mixing ports and subsequently encounters jets of air from the secondary mixing ports, which may be of greater size than the primary mixing ports.

Referring to Fig. 3, a prior art mixing port 42 is defined by generally circular openings provided in each of the inner and outer walls 32 and 34, for allowing air to pass into the combustor 30. The mixing port 42 has a short generally cylindrical wall 44 which is integral with the inner wall 32.

The direction of air flow through the mixing port 42 is generally as indicated by the arrow in Fig. 3. This results in hot spots in the areas marked with an "H" in Fig. 3. In these areas, the flow tends to separate and generates significant reversals of hot gas from a more central, hot region of the combustor 30.

Referring to Fig. 4, a wall arrangement according to the invention includes a smoke chute 46 of generally cylindrical shape, but with a cut-away upstream part 48. The smoke chute 46 is formed integrally with an inner wall tile 36. A downstream part 50 of the smoke chute 46 has an axial length of about 10 to 15mm, extending inwardly towards the centre region of the combustor 20. The smoke chute 46 acts as a baffle, increasing the radial component of the direction of air flow into the combustor. Thus the air penetrates further into the combustor and mixes better with the fuel than is the case with the prior art mixing port of Fig. 3. This tends to reduce emissions.

In the smoke chute 46 of Fig. 4, there is a tendency for hot spots to form in the regions marked H, in a similar manner to that discussed in relation to the prior art mixing port. This can result in the burning away of the chute in

the hot regions. To minimise this burning, the chute is cut-away at the upstream part 48 such that essentially any metal which would be burnt away is removed. The upstream part 48 of the chute is not significant in directing the air flow and thus the removal of this metal does not adversely affect its performance.

To prevent overheating of the downstream part 50 of the smoke chute 46, an opening 52 is provided between the inner wall 32 and the smoke chute 46. This opening 52 allows relatively high pressure cool air to pass as indicated by the arrow from a region external of the outer wall 34, into the combustor 30. The air flows over the downstream part 50 of the smoke chute 46, preventing it from overheating.

Figs. 5 to 11 show alternative embodiments of the invention in which corresponding elements are given the same reference numerals.

Referring to Fig. 5, the smoke chute 46 is again formed integrally with an inner wall tile 36, and is generally similar to the smoke chute of Fig. 4. However the downstream part 50 is cooled rather differently. In this case, an opening 54 is provided in the inner wall tile 36 adjacent to the smoke chute 46. Air within the space 56 between the inner and outer walls 32 and 34 is at a lower pressure than the external air but has a higher pressure than that inside the combustor 30. This air therefore flows over the downstream part 50 of the smoke chute 46, cooling that part.

Referring to Fig. 6, a smoke chute 46 is again formed integrally with an inner wall tile 36, but in this case includes a downstream part 58 which extends outwardly beyond the outer wall 34 away from the combustor 30. This downstream part 58 increases the radial component of air flow entering the combustor 30, improving mixing and reducing emissions.

Referring to Fig. 7, a smoke chute 46 is again formed integrally with an inner wall tile 36. The smoke chute 46 is of a generally similar shape to that of Fig. 5. However the

walls of the smoke chute are of double thickness, with an air gap 60 being provided therebetween. High pressure cool air is able to enter the air gap 60 and to pass through perforations 61 into the combustor 30, thus cooling the walls of the smoke chute 46.

Referring to Fig. 8, a smoke chute 46 is in this case not formed integrally with either of the walls of the combustor, but is fixed to the outer wall 34. The smoke chute 46 is fixed via a flange 62, and may be welded or brazed to the outer wall 34. A small gap 64 is provided between the smoke chute 46 and the adjacent tile 36 of the inner wall 32, to allow expansion of the inner wall 32, which reaches higher temperatures than the outer wall 34. An additional air flow gap 66 is provided between the outer and inner walls 34 and 32 adjacent to the smoke chute 46, for allowing air from within the space 56 between the outer and inner walls 34 and 32 to flow past the walls of the smoke chute 46, effecting cooling of those walls.

Fig. 9 illustrates a similar embodiment to that of Fig. 8, but in this case cooling air is provided from externally of the outer wall 34. A small air flow gap 68 is provided in the flange 62 on the downstream side of the smoke chute 46, for allowing cooling air to pass over the downstream wall 50 of the smoke chute 46.

Referring to Fig. 10, the smoke chute 46 is again affixed to the outer wall 34 via a flange 62, but in this case a sliding seal ring 70 is trapped between the inner and outer walls 32 and 34. Air flow takes place from the space 56 between the inner and outer walls into the combustor 30, over the walls of the smoke chute 46.

Fig. 11 illustrates an embodiment similar to that of Fig. 10, but in this case a pin 72 is provided to prevent relative rotation of the smoke chute 46 and the outer walJ 34.

As an alternative, each of the embodiments shown in Fi‹ 4, 5 and 7 to 11 the smoke chutes 46 can be provided wi

thermally resistant material in addition to, or instead of, cooling air passing over the walls of the smoke chutes 46.

The thermally resistant material is in the form of a thermal barrier coating 100 (represented by dashed lines) and protects the smoke chutes 46 from overheating.

There are thus provided various embodiments of a smoke chute which improve mixing of fuel and air within a combustor, and which minimise problems of overheating of the smoke chute.

Another aspect of the invention relates to the use of a mixing port, which may be a smoke chute, to fix a tile 36 of the inner wall 32 to the outer wall 34.

Referring to Fig. 12, in a first embodiment of this invention a mixing port 80 is formed integrally with a wall tile 36. A head 82 of the mixing port 80 is provided with upper and lower circumferential projections 84 and 86 defining an annular recess 88 therebetween. This recess 88 houses a circlip 90 (shown in plan in Fig. 13) which is used to affix the mixing port 80 to the outer wall 34. In this way, the mixing port 80 is used to attach the inner wall tile 36 to the outer wall 34 and to prevent relative movement therebetween.

Referring to Fig. 14, in an alternative embodiment of the invention a split ring 92 is housed within the recess 88 and welded in place, in order to affix the mixing port 80 to the outer wall 34.

Referring to Fig. 15, the mixing port 80 need not be formed integrally with the wall tile 36. Alternatively, the mixing port may be crimped or swaged in place, as illustrated.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that th(Applicant claims protection in respect of any patentabl feature or combination of features hereinbefore referred and/or shown in the drawings whether or not particu

emphasis has been placed thereon.

Claims

1. A wall structure for a gas turbine engine combustor, the wall structure including outer and inner walls defining a space therebetween, the inner wall including a number of wall elements, wherein at least one mixing port is provided within the wall structure for providing air to the combustor and wherein the mixing port includes baffle means projecting internally beyond the inner wall or externally beyond the outer wall, for directing air generally towards an inner region of the combustor.

2. A wall structure according to claim 1 wherein the wall elements comprise discrete tiles.

3. A wall structure according to claim 1 or claim 2 wherein the baffle means is provided at a downstream side of the mixing port.

4. A wall structure according to any preceding claim wherein the baffle means is integral with a wall element of the inner wall.

5. A wall structure according to any of claims 1 to 3 wherein the baffle means is formed separately from the wall structure and affixed to the outer wall.

6. A wall structure according to any preceding claim wherein the baffle means forms at least part of a chute member having a generally cylindrical shape.

7. A wall structure according to claim 6 wherein a downstream part of the chute member extends further internally or externally than an upstream part.

8. A wall structure according to any preceding claim wherein the baffle means projects internally beyond the inner wall.

9. A wall structure according to claim 8 wherein means are provided for directing cooling air over the baffle means from a region external to the outer wall.

10. A wall structure according to claim 9 wherein an opening

is provided between the chute member and an adjacent part of the wall structure, the opening allowing air to flow from a region external to the outer wall into the combustor, over the baffle means.

11. A wall structure according to claim 9 wherein the chute member has two generally parallel walls, such that air may flow from a region external to the outer wall of the wall structure into a space between the two walls of the chute member, thereby to cool the baffle means.

12. A wall structure according to claim 8 wherein the cooling air is directed from a space between the inner and outer walls.

13. A wall structure according to claim 12 wherein an opening is provided in the inner wall or between the chute member and an adjacent part of the inner wall, the opening allowing air to flow from the space between the inner and outer walls into the combustor, over the baffle means.

14. A wall structure according to claim 13 wherein a sliding seal ring is provided in the opening.

15. A wall structure according to any of claims 8 to 14 wherein retaining means are provided to prevent rotation of the chute member relative to the wall structure.

16. A wall structure according to any of claims 8 to 15 wherein the baffle means is provided with a thermally resistant material.

17. A wall structure according to claim 16 wherein the thermally resistant material is provided on at least part of an external surface of the baffle means.

18. A wall structure according to claim 17 wherein the thermally resistant material is provided on at least a part of said surface facing downstream.

19. A wall structure according to claim 18 wherein the thermally resistant material is provided substantially around the whole surface of the baffle means.

20. A wall structure according to any of claims 16 to 19 wherein the thermally resistant material is in the form of a

thermal barrier coating.

21. A wall structure according to any preceding claim, wherein the mixing port is affixed to the inner wall and is affixed to the outer wall with a circlip or split ring fastening.

22. A wall structure for a gas turbine engine combustor, the wall structure including at least one outer wall and at least one inner wall and the inner wall including a number of wall elements, wherein at least one mixing port is provided within the wall structure for providing air to the combustor, the mixing port being affixed to the inner wall and being affixed to the outer wall with a circlip or split ring fastening.

23. A wall structure according to claim 22 wherein the mixing port is integrally formed with a wall element of the inner wall.

24. A wall structure according to claim 22 wherein the mixing port is crimped or swaged to the wall element of the inner wall.

25. A wall structure substantially as herein described with reference to any of Figs. 2 to 15 of the drawings.

26. A gas turbine engine combustion chamber including a wall structure according to any preceding claim.

27. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

Application No:	GB 0004706.8	**Examiner:**	Paul Jenkins
Claims searched:	1-21 & 25-26	**Date of search:**	17 March 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F4T (TAR4; TAD, TAE, TAF)

Int Cl (Ed.7): F23R 3/04, 3/06, 3/08

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2074307 A	(UNITED TECHNOLOGIES) Whole document relevant	1-3, 5-9, 11-13 & 15
X	GB 2017827 A	(GENERAL ELECTRIC) Figures 1-5 see air dilution holes 23	1 & 3-13
X,E	EP 0937946 A2	(ROLLS-ROYCE) Whole document especially figure 4	1-21
X	EP 0178820 A1	(WESTINGHOUSE) See scoops 30 & 32	1, 3-6, 8-13 & 15
A	US 5235805	(BARBIER) See figures	——

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
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